BHARAT HEAVY ELECTRICALS LIMITED
HEEP: HARDWAR-249 403 (UK)
Fax: 01334-226462, Phone: 01334-284144
E-mail: ajayk@bhelhwr.co.in

Tender no: PPX-F&HE/EOI/SL/16-17/02 **Due Date: 10/10/2016**

Notice for Expression of Interest for empanelment of New Vendors

The Heavy Electrical Equipment Plant (HEEP) located in Haridwar, is one of the major manufacturing plants of BHEL. The core business of HEEP includes design and manufacture of large steam and gas turbines, turbo generators, condenser and generators and so on.

We are looking for reputed vendors having capability to supply Turbine Blade Flats Grade X20Cr13 (HW10786 Rev: 06), X22CrMoV121 (HW10687 Rev: 06), X19CrMoNbVN11-1 (HW10670 Rev: 06) & X12CrMoWVNbN10-1-1 (HW10663 Rev: 05)
Approx. annual requirement is 71 MT, 163 MT, 675 MT, 410 MT for Material Grade X12, X19, X20 & X22 respectively.

Contact persons:

Mr. Yashpal Yadav
Designation: Engr (PPX-F & HE)
Email: yash-pal@bhelhwr.co.in
Phone No: +91 1334-284144
Mobile: +91 9012227802

Mr. Ran Singh Chauhan
Designation: Sr. Mgr (PPX-F & HE)
Email: rschn@bhelhwr.co.in
Phone No: +91 1334-281478
Mobile: +91 9410395890

Mr. Ajay Kr Gupta
Designation: SDGM (PPX & AIX-F)
Email: ajayk@bhelhwr.co.in
Phone No: +91 1334-284570
Mobile: +91 9410395962

The offers received will be technically evaluated by BHEL & successful short listed parties will be asked to submit their detailed Techno-Commercial offers through formal NIT/Enquiry for our future requirements. Vendors shall confirm that there is no deviation with respect to BHEL Specifications. However deviations, if any are to be listed as a separate attachment. The offers that do not meet the substantial requirements of our specifications are liable to be ignored.

Following documents are to be necessarily filled and submitted along with the technical offer:

1. Details/ Documents in support of Specification/PQR (**Annexure-I up-loaded**)
2. Quality Requirements **(Annexure- II) &** Quality Plan format **(Annexure-III).**
3. Supplier/Vendor Registration Form- Go through online supplier registration portal https://supplier.bhel.in/. After filling the online registration form send the copy of same along with your offer within due date.
4. Details of Manufacturing Facility
5. Company Profile.
6. Financial report of the company.
7. Past experience along with documentary proof.

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Only Technical BID along with the documents mentioned above should be sent and the envelope containing the offer shall be duly sealed and super scribed as "**Technical Offer for (ITEM NAME) AGAINST Tender No. PPX-F&HE/EOI/SL/16-17/02**

Due Date-10.10.2016, SUBMITTED BY (Name of company)"

- This notification shall be published on ***www.bhel.com***, ***www.tenders.gov.in*** and ***www.bhelhwr.co.in***
- Last date for downloading tender documents shall be 09.10.2016 till 1700 Hrs.(IST). Tenders will be received up to 13:45 Hrs. (IST) on 10.10.2016 will be considered and opened on the same day at 14:00 Hrs. (IST) in the Tender Room BHEL HEEP, Haridwar.
- Technical Offers complete in all respect must be addressed to "Shri Ajay Kr Gupta, SDGM (PPX & AIX- F)".
- EMD & Tender fee are not applicable.
- The Quotation should be from the Principal / Original Manufacturer, failing which the quotation may likely to be ignored. In Case the quotation is submitted through agent, the quotation must accompany original authorization letter.
- Late offers will not be considered in any case. BHEL will not be responsible for any type of postal delay / incomplete information from vendor.
- Amendments / Corrigendum, if any, will be hosted on our web site only.

For any further details please log on to *www.bhel.com* or ***www.tenders.gov.in*** or ***www.bhelhwr.co.in***

(Ajay Kr Gupta)
SDGM (PPX & AIX-F)

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ANNEXURE-I

Expression of Interest for rectangular flat bars for turbine of material grade X20Cr13 (HW10786, Rev06), X22CrMoV121 (HW10687, Rev06) X19CrMoNbVN11-1 (HW10670, Rev06) & X12CrMoWVNbN10-1-1 (HW10663, Rev 05)

1. Rectangular flat bars of above mentioned material grade are used for manufacturing of milled blades for Steam Turbines of rating 250 to 800 MW.

2. Vendor to submit their manufacturing experience of flats in material grade X20Cr13/X22CrMoV121/X19CrMoNbVN11-1/X12CrMoWVNbN10-1-1 in rectangular cross sectional sizes (width X thickness e.g. 58mmx32mm, 96x46mm etc.) with length 3000 – 6000 mm. Following details of past supplies to be submitted in support of experience:
    - Un-priced purchase order,
    - Name of customer, quantity supplied
    - Year of supply,
    - Cross Section (width X thickness X length) & Weight.

3. Test certificate of past supplies for above material grades, witnessed by third party (like TUV/Lloyd/BVQI etc.), shall be furnished for review.

4. Vendor to furnish in house manufacturing facility for steel melting, secondary refining including Electro Slag re-melting (if available), rolling / forging, heat treatment and straightening to manufacturer rectangular bars.

5. Vendor to furnish in house testing facilities to carry out testing as per the requirements of BHEL specification. In case of outsourcing any test, vendor to agree to carry out testing at Government accredited labs only.

6. Prerequisite requirement for approval of a new vendor is successful process qualification as per clause 9.0 of specification of respective material grade. Process qualification is mandatory for supplier's each manufacturing plants. Vendor to submit results of process qualification as per Clause 9.0 of respective specification, if available.

Note: All documents submitted must be in English language.

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ANNEXURE-II

Quality Requirements-

- Vendor to furnish manufacturing plan and quality plan along with offer for BHEL review and approval. Quality plan to be submitted in the enclosed format only and to be in line with BHEL specification. Refer annexure-III for quality plan format.

- Inspection shall be by TPI (LRS/TUV/BV) for import and BHEL nominated agency 'TUV' for indigenous as per finally BHEL approved Quality Plan.

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ANNEXURE-III

(Quality Plan Format)

MANUFACTURER'S NAME AND ADDRESS		QUALITY PLAN				TO BE FILLED BY BHEL	TO BE FILLED BY BHEL
BHEL	VENDOR'S NAME	ITEM		QP NO.			
				REV			
		DRG. NO.	AS PER PO				
		SPEC.	AS PER PO				
		REV		Page 1 of 1			

SL. NO.	COMPONENT & OPERATIONS	CHARACTERISTICS	CLASS	TYPE OF CHECK	QUANTUM OF CHECK	REFERENCE DOCUMENT	ACCEPTANCE NORMS	FORMAT OF RECORDS		AGENCY			REMARKS
										M	B	N	
1	2	3	4	5	6	7	8	9	D	10			11

		LEGEND: ! RECORDS IDENTIFIED WITH 'TICK' SHALL BE ESSENTIALLY INCLUDED BY CONTRACTOR IN QA DOCUMENTATION. M: MANUFACTURER / SUBCONTRACTOR B: BHEL / NOM. INSPECTION AGENCY N: CUSTOMER INDICATE 'P' PERFORM 'W' WITNESS AND 'V' VERIFICATION	FOR CUSTOMER USE	
MANUFACTURER/SUBCONTRACTOR		ALL 'W' INDICATED IN COLUMN 'N' SHALL BE 'CHP' OF CUSTOMER		APPROVED BY

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ANNEXURE-IV

SPECIFICATION

13% Cr Stainless Steel Bars for Turbine Blades
GRADE: X20Cr13+QT800

1.0 General:

This specification governs the quality of Steel rectangular bars in steel grade X20Cr13, material no. 1.4021, EN10088-3.

2.0 Application:

For machining of blades for Steam Turbine.

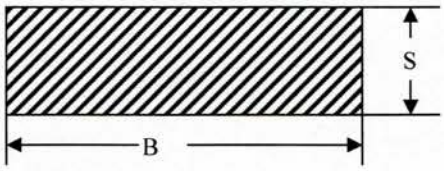
3.0 Condition of Delivery:

Rolled or Forged and Heat Treated.

4.0 Dimension and Tolerances :

The dimensions shall be as per purchase order. Unless otherwise stated in the purchase order, length of bars shall be 3 - 6 meters with maximum 10% short down to 1 meter.

Tolerance and straightness of bars shall be as follows:



B, width across flats (mm)	Max allowable deviation on B, mm	S, thickness (mm)	Max allowable deviation on S, mm
B ≤ 35	+ 1.5	S ≤ 20	+ 1
35< B ≤ 75	+ 2	20< S ≤ 40	+ 2
B > 75	+ 3	S > 40	+ 3

Twisting and bending of the bars shall not exceed 0.001X Length of bar limited to maximum 2mm in any one meter length of the bar. Bulging on the sides shall not be more than 0.01 X B and 0.02 X S respectively.

5.0 Manufacture:

Degassed steel (e.g. vacuum degassed) shall be used. Cast ingot is to be used as initial material for production of the bars.

The manufacturing process must ensure a homogenous grain structure over the entire length of the bar and the bar cross section.

6.0 General Requirements:

- Prerequisite requirement for approval of a new vendor is a successful Process qualification. Manufacturing process established during this shall be the basis for future manufacture.

				नाम NAME	हस्ताक्षर एवं दिनांक SIGNATURE & DATE
TSX	V Srivastava	3/11/15			
PSC	V K Chauhan	28.10.15			
QAX	U. K. Panda	28.10.15	अनुवादक TRANSLATED BY		
STE	P. K. Bansal	29/X/15	निर्माणकर्ता WORKED BY	ASHOK RAWAT	AshokRawat 26/10/15
			जांचकर्ता CHECKED BY	ASHISH RANJAN	Aranjan 26/10/15
सहमत विभाग AGREED DEPTT.	नाम NAME	दिनांक एवं हस्ताक्षर DATE & SIGNATURE	पर्यवेक्षणकर्ता SUPERVISED BY	GOPAL KRISHNAN	Gkrishnan 26/10/15

CHANGES W.R.T. REV. 05: REFER CLAUSE NO. 13

स्वीकृति : संस्थान मानक समिति
APPROVED : PLANT STANDARDS COMMITTEE

Gr. No 2.60

REV 06			निर्माण PREPARED : MTE	जारी : मानक विभाग ISSUED : STANDARDS DIVISION	दिनांक DATE : 30.03.1992
3/11/15					

हस्ताक्षर एवं दिनांक SIGN & DATE 3/11/15

सामग्री सूची संख्या INVENTORY NO. R-2182

- Manufacturing plan shall be prepared and submitted after successful process qualification. Manufacturing plan shall include specific information on manufacturing like rolling temperature, reduction ratio, heat treatment temperature, hardening method and soaking time, rate of heating and cooling etc. Test instructions for nondestructive and destructive testing are to be provided in the manufacturing and testing plan.
- Product and process qualification is mandatory for supplier's each manufacturing plants.
- For new supplier, process qualification shall be required for three purchase orders.
- If necessary, BHEL may ask for process qualification for verification of manufacturing reliability from regular suppliers also.
- Any change in the agreed manufacturing plan shall be informed to BHEL. BHEL will review the requirement of renewed process qualification.

7.0 Heat Treatment:

Hardening has to be done in accordance with EN 10088 - 3, + QT 800 in line with Table A.2 (950 - 1050°C /air or liquid quenching).

Tempering must be done at a temperature ≥ 650°C.

A fully transformed and tempered martensitic microstructure must be present over the entire cross section.

Hardening and tempering in bundles are not allowed. Suitable gaps between two bars are to be ensured during heat treatment for uniformity of properties.

If bars need to be straightened after the heat treatment, a stress relieving heat treatment shall be performed after completion of entire straightening process. Stress relieving is to be carried out at 20 - 30°C below the tempering temperature with a subsequent slow cooling.

The lowest possible residual stresses shall be targeted. Distortion of the finish machined part due to residual stresses from the manufacturing process or heat treatment process shall not occur.

8.0 Properties and their verification:

8.1 Chemical Composition:

Heat analysis in weight %

C	Si	Mn	P	S	Cr	Ni
0.17 -0.22	0.10 - 0.60	0.30 - 0.80	≤ 0.030	≤ 0.020	12.5 - 14.0	0.30 - 0.80

Cobalt content must be specified in the inspection certificate for information purposes.

8.2 Properties and Microstructure:

The specimens shall be taken in the longitudinal direction in accordance with Attachment 1. The properties described below shall be determined at room temperature in the delivery condition, i. e. after the last heat treatment including any stress relieving heat treatment.

The metallographic investigations shall be performed on the hardest and softest bar with an area of at least 320mm^2 each. The areas to be investigated must be in the longitudinal direction. The longitudinal direction must be indicated in the documentation.

8.2.1 Mechanical Properties:

Hardness of the bars in a test unit shall be verified by Brinell hardness testing in accordance with ISO 6506 -1, HBW10/3000 or HBW 5/750 may be used.

The surface of the bar shall be prepared in the area of the hardness measurement so that the result is not affected by the surface condition.

Hardness testing shall be performed on 10% of each test unit but at least on 10 bars or on each bar if test unit is less than 10 bars. The greatest resulting difference in hardness shall not exceed 35HBW.

Mechanical properties shall be determined on the hardest and softest bar determined in a test unit.

Tensile testing shall be performed in accordance with ISO 6892 -1 or ASTM E8M (round specimen with L_0 = 50mm and d_0 = 10mm) or ASTM E8 (standard specimen in accordance with Figure 8).

Standard specimens Charpy (V-notch) in accordance with ISO 148 -1 shall be used for determining the absorbed impact energy.

The following properties must be achieved at room temperature:

0.2 % Proof Stress (N/mm^2)	Tensile Strength (N/mm^2)	Elongation After Fracture (%)	Reduction in area %	Impact Energy (J)[1]	Hardness HBW
≥ 600	800 - 950	≥ 15	≥ 50	≥ 20	240 - 280

[1] Average of 3 specimens and minimum value for two specimens in accordance with EN10021, where the lowest value shall be at least 14 Joule.

8.2.2 Microstructure:

Microstructure must be uniform, without porosity, excessive segregation or other inhomogeneities.

8.2.2.1 Cleanliness:

The cleanliness shall be determined as per ASTM E45 method A. Acceptance criteria:

Inclusion: Thin Series

Type A, B, C: 2 max Type D: 2.5max

Inclusions: Heavy Series

Type A, B, C, D: 1.5max

Maximum Number and dimension of globular inclusions (type D)

IR (D) = n1 + 2.5n2, IR (D) is converted to an area of $160mm^2$

IR (D) ≤ 10

n = number of globular inclusions

n1 (25-50µm); n2(51-75µm)

Any material discontinuities present at the inclusion must also be accounted for in determining the size of globular inclusion.

Inclusions > 75 µm, including any material discontinuities, are not allowed.

8.2.2.2 Delta Ferrite content and grain size:

- **Delta ferrite content shall be < 5%.** The determination of delta ferrite content shall be performed based on analysis methods in accordance with ASTM E45 Method A, "Worst field method" with V=100:1.

- **An average grain size of 4 or finer** has to be achieved. Grain size shall be determined on the martensitic secondary grain structure in accordance with ASTM E112 or ISO643. A deviation of more than 2 grain sizes in size of individual's grains from the average grain size is not allowable.

8.3 Non-destructive Testing:

8.3.1 Test Scope:

The following Non – destructive inspections shall be performed in the as delivered condition:

- Visual inspections of all bars
- Ultrasonic examination of all bars in accordance with TWP 1204. 100% of the volume must be tested in accordance with the recording level.

8.3.2 Recording level and acceptance criteria:

- Indications of surface defects such as rolled marks shall be ground out to investigate their depth at least at both ends, in the middle of the indication and at an interval of approx. 250mm.
- Surface defects with a depth extension of ≥ 1mm are not allowable, and these areas shall be cut out of the bar.
- Ultrasonic examination shall be carried out on all bars in accordance with TWP 1204.
- Defects above the recording level are not acceptable and must be cut out.
- It shall be confirmed in writing to the BHEL that bar sections containing defects above the recording level have been cut out of the bar.
- The acceptance of material at vendor's works does not relieve the supplier of his responsibility for defects discovered at later stages.

8.3.3 Material Identity Test:

An identity test must be conducted in the as – delivered condition on all bars.

9.0 Process Qualification:

In addition to testing as per clause 8.0 of this specification, following additional testing shall be performed in process qualification (see Attachment 2). **All test results carried out during process qualification shall be submitted to BHEL for approval.**

- **Tensile tests[1]:**
  The strength values (0.2% Proof Stress and Tensile Strength) in the transverse direction (specimen orientation ZQ) shall not differ by more than 10% from the corresponding longitudinal values.
- The absorbed impact energy in the transverse direction (KQ 1 -3) should not differ by more than 25% from the values in the longitudinal direction (Kl at room temperature).
- **FATT:** Determination of FATT (fracture appearance transition temperature) in accordance with ASTM A370. The FATT should be evaluated based on SEP 1670 (software). The test scope must include at least 10 specimens. FATT < 30°C is to be achieved.

In accordance with ISO 6892 -2, a tensile test (in longitudinal direction) has to be performed at 500°C. The following properties must be achieved:

0.2 % Proof Stress (N/mm^2)	Tensile Strength (N/mm^2)	Elongation After Fracture (%)	Reduction in area (%)
≥ 380	≥ 480	≥ 20	≥ 60

[1] **For case where standard specimens in transverse direction cannot be made:-**

- For tensile test specimens, a round specimen with $L_0 = 5\ d_0$ or a flat specimen with a proportionality factor of k= 5.65. Proportional specimens in accordance with Fig 8 shall be used if ASTM E8 is applied.

- An undersized specimen in accordance with ISO 148 -1 for impact test specimen. Undersize dimension to be reported.
- If dimension do not allow testing in the transverse direction, even with special specimen, testing will be carried out in the longitudinal direction only.

Intergranular Fracture Determination Test:

The fraction of Intergranular fracture shall be determined over the entire brittle fracture portion of the fracture surface of the impact test specimens tested at room temperature. The fraction of Intergranular fracture shall not exceed 10%. This test is not required for materials which indicate ≥90% ductile fracture at room temperature.

Magnetic Particle Test:

Performance of MT testing by the magnetic flux leakage method, alternating current phase shifted and a field strength of 20 – 65A/cm.

Distribution, type and size of grain structure in-homogeneities (e.g. segregation or delta ferrite) shall not result in MT indications.

10.0 Identification Marking:

All bars are to be marked with following information:

- Purchase Order Number
- Size
- Material Grade
- Supplier Identification

The details are to be clearly stamped and encircled by oil paint. Each bar shall be painted with pink colour with white strip on both ends. All the bars shall be suitably packed to protect them against corrosion and damage during transportation.

Bars having maximum and minimum hardness (from which test samples are taken) shall be clearly marked by oil paint for easy identification. Their respective hardness values shall also be punched on these bars.

11.0 Documentation:

Prior to, but in no case later than the delivery of the material, an inspection certificate as per EN 10204 shall be provided to BHEL in duplicate; this certificate must contain the following data:

(a) Material code no and P.O. number
(b) Material designation
(c) Heat no., heat analysis and melting methods
(d) Complete information on all heat treatments performed
(d) Mechanical test results including hardness range and the metallurgical examination.
(e) Results of non-destructive tests, UT inspection report
(f) Confirmation of the material identity check
(g) Dimensions and visual inspection reports

12.0 Cross Referred Standard:

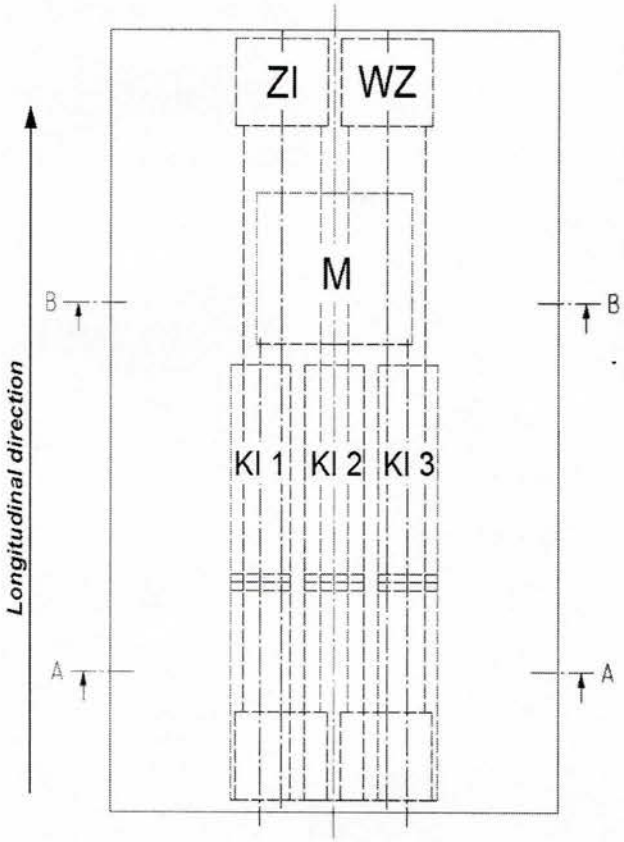
ISO 6892-1, EN10088-3, EN10021, ASTM E8M, ISO148-1, EN10021, ASTM E45, TWP1204, ASTME8, ASTM E112, ISO643, ASTM A370, EN10204

13.0 Modification with respect to last revision:

- Clause 4 modified.
- Clause 7 modified.

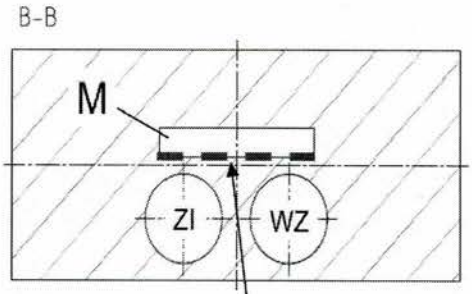
Attachment 1

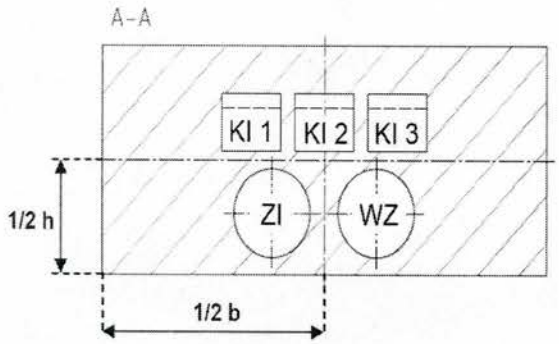
Standard Testing



Label	Specimen
ZI	*Tensile Specimen Centre*
WZ*	*Hot Tensile Specimen*
KI 1 - KI 3	*Notched Impact Specimen Centre*
M	*Metallographic Specimen*

* *if required in material* **specification**

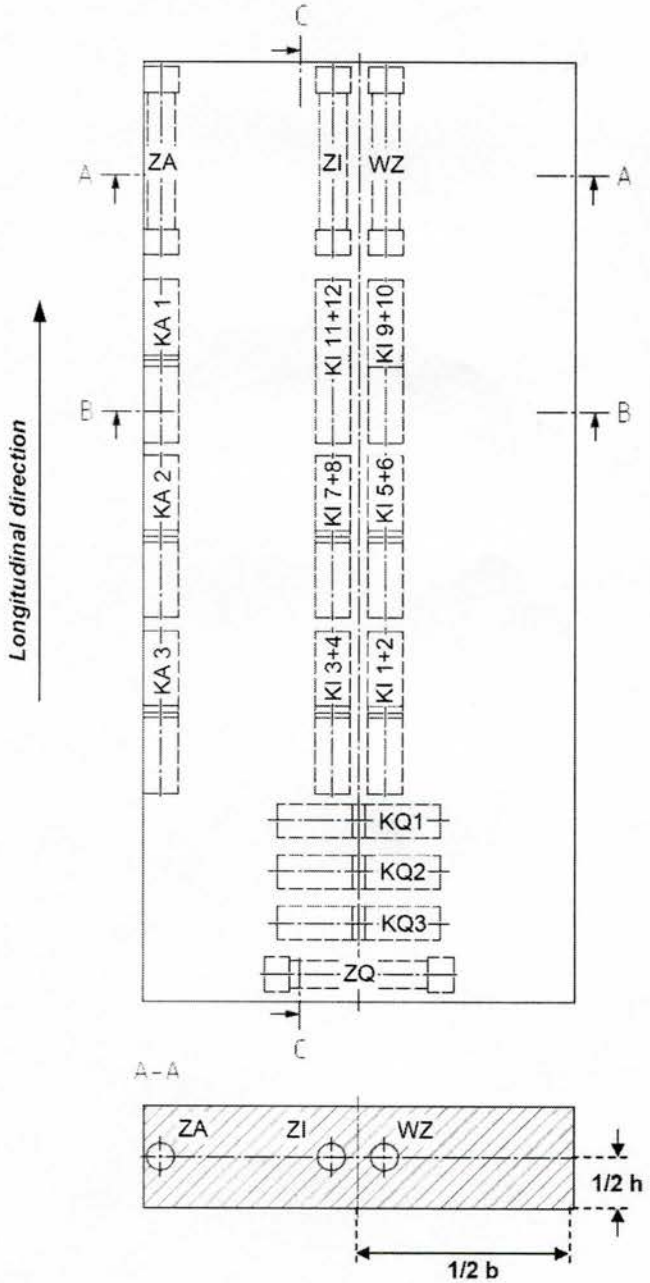




Lower Surface *of the Metallographic Specimen has to be examined. Longitudinal direction must be indicated in the documentation. A ≥ 320 mm²*

Attachment 2, Page 1/2

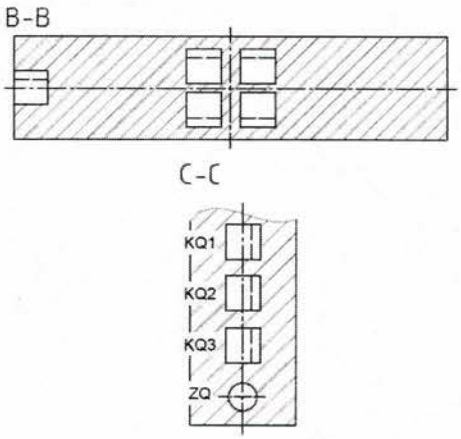
Process Qualification



Label	Specimen
ZI	*Tensile Specimen Centre*
ZA	*Tensile Specimen Rim*
ZQ	*Tensile Specimen Transverse*
WZ*	*Hot Tensile Specimen*
KI 1 - KI 12	*Notched Impact Specimen Centre (FATT)*
KA 1 - KA 3	*Notched Impact Specimen Rim*
KQ 1 - KQ 3	*Notched Impact Specimen Transverse*

** if required in material* **specification**

Note the notch positions of the notch impact specimens (see B - B and C - C).

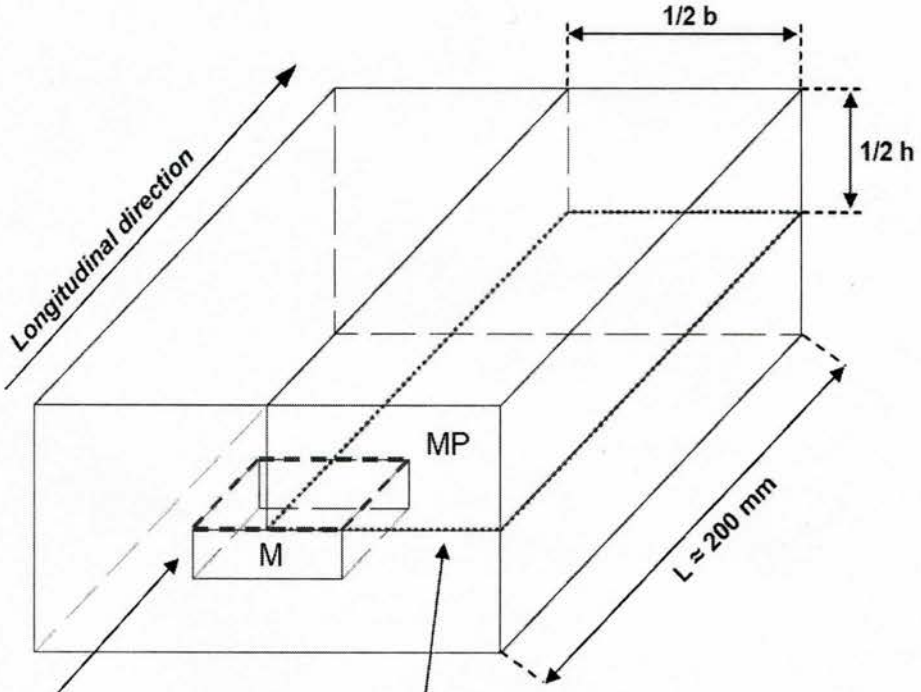


REV 06	निर्माणकर्ता WORKED BY	Ashish Ranjan	ARanjan	26.10.15
	जांचकर्ता CHECKED BY	Gopal Krishnan	Gkrishnan	26.10.15

Attachment 2, Page 2/2

Process Qualification

Label	*Specimen*
M	*Metallographic Specimen*
MP	*Specimen for Magnetic Particle Test*



Upper Surface *of the Metallographic Specimen has to be examined. Longitudinal direction must be indicated in the documentation. A ≥ 320 mm²*

Lower Surface *of the specimen has to be examined in Magnetic Particle Test .*

HEAT RESISTANT STEEL BARS FOR TURBINE BLADES
GRADE: X22CrMoV121 +QT2

1.0 General:

This specification governs the quality of Steel rectangular bars in steel grade X22CrMoV121, material no. 1.4923 EN10269.

2.0 Application:

For machining of blades for Steam Turbine.

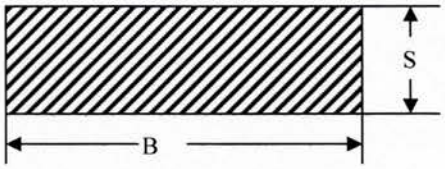
3.0 Condition of Delivery:

Rolled or Forged and Heat Treated.

4.0 Dimension and Tolerances :

The dimensions shall be as per purchase order. Unless otherwise stated in the purchase order, length of bars shall be 3 - 6 meters with maximum 10% short down to 1 meter.

Tolerance and straightness of bars shall be as follows:



B, width across flats (mm)	Max Allowable deviation on B, mm	S, thickness (mm)	Max Allowable deviation on S, mm
B ≤ 35	+ 1.5	S ≤ 20	+ 1
35< B ≤ 75	+ 2	20< S ≤ 40	+ 2
B > 75	+ 3	S > 40	+ 3

Twisting and bending of the bars shall not exceed 0.001X Length of bar limited to maximum 2mm in any one meter length of the bar. Bulging on the sides shall not be more than 0.01 X B and 0.02 X S respectively.

5.0 Manufacture:

Degassed steel (e.g. vacuum degassed) shall be used. Cast ingot is to be used as initial material for production of the bars.

The manufacturing process must ensure a homogenous grain structure over the entire length of the bar and the bar cross section.

6.0 General Requirements:

- Prerequisite requirement for approval of a new vendor is a successful Process qualification. Manufacturing process established during this shall be the basis for future manufacture.

				नाम NAME	हस्ताक्षर एवं दिनॉक SIGNATURE & DATE
TSX	V Srivastava	31/11/15			
PSC	V K Chauhan	30.10.15			
QAX	U. K. Panda	30.10.15	अनुवादक TRANSLATED BY		
STE	P. K. Bansal	29/X/15	निर्माणकर्ता WORKED BY	ASHOK RAWAT	Ashok Rawat 26.10.15
			जांचकर्ता CHECKED BY	ASHISH RANJAN	A Ranjan 26/10/15
सहमत विभाग AGREED DEPTT.	नाम NAME	दिनॉक एवं हस्ताक्षर DATE & SIGNATURE	पर्यवेक्षणकर्ता SUPERVISED BY	T S GOPAL KRISHNAN	26/10/15

CHANGES W.R.T. REV 05; REFER CLAUSE NO. 13

स्वीकृति : संस्थान मानक समिति
APPROVED : PLANT STANDARDS COMMITTEE

Gr. No 2.60

REV 06			निर्माण PREPARED : MTE	जारी : मानक विभाग ISSUED : STANDARDS DIVISION	दिनॉक DATE 31.12.1985
3/11/15					

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सामग्री सूची संख्या INVENTORY NO P-2006

- Manufacturing plan shall be prepared and submitted after successful process qualification. Manufacturing plan shall include specific information on manufacturing like rolling temperature, reduction ratio, heat treatment temperature, hardening method and soaking time, rate of heating and cooling etc. Test instructions for nondestructive and destructive testing are to be provided in the manufacturing and testing plan.
- Product and process qualification is mandatory for each of the supplier's manufacturing plants.
- For new supplier, process qualification shall be required for three purchase orders.
- If necessary, BHEL may ask for process qualification for verification of manufacturing reliability from regular suppliers also.
- Any change in the agreed manufacturing plan shall be informed to BHEL. BHEL will review the requirement of renewed process qualification.

7.0 Heat Treatment:

Hardening has to be done in accordance with EN 10269 + QT2 in line with Table B .1 (1020 - 1070°C /air or liquid quenching).

Tempering must be done at a temperature ≥ 650°C.

A fully transformed and tempered martensitic microstructure must be present over the entire cross section.

Hardening and tempering in bundles are not allowed. Suitable gaps between two bars are to be ensured during heat treatment for uniformity of properties.

If bars need to be straightened after the heat treatment, a stress relieving heat treatment shall be performed after completion of entire straightening process. Stress relieving is to be carried out at 20 - 30°C below the tempering temperature with a subsequent slow cooling.

The lowest possible residual stresses shall be targeted. Distortion of the finish machined part due to residual stresses from the manufacturing process or heat treatment process shall not occur.

8.0 Properties and their verification:

8.1 Chemical Composition:

Heat analysis in weight %

C	Si	Mn	P	S	Cr	Mo
0.18 - 0.24	0.10 - 0.50	0.30 - 0.80	≤ 0.020	≤ 0.020	11.0 - 12.5	0.80 - 1.20

Ni	V
0.30 - 0.80	0.25 - 0.35

8.2 Properties and Microstructure:

The specimens shall be taken in the longitudinal direction in accordance with Attachment 1. The properties described below shall be determined at room temperature in the delivery condition, i. e. after the last heat treatment including any stress relieving heat treatment.

The metallographic investigations shall be performed on the hardest and softest bar with an area of at least 320mm^2 each. The areas to be investigated must be in the longitudinal direction. The longitudinal direction must be indicated in the documentation.

8.2.1 Mechanical Properties:

Hardness of the bars in a test unit shall be verified by Brinell hardness testing in accordance with ISO 6506 -1, HBW10/3000 or HBW 5/750 may be used.

The surface of the bar shall be prepared in the area of the hardness measurement so that the result is not affected by the surface condition.

Hardness testing shall be performed on 10% of each test unit but at least on 10 bars or on each bar if test unit is less than 10 bars. The greatest resulting difference in hardness shall not exceed 35HBW.

Mechanical properties shall be determined on the hardest and softest bar determined in a test unit.

Tensile testing shall be performed in accordance with ISO 6892 -1 or ASTM E8M (round specimen with L_0 = 50mm and d_0 = 10mm) or ASTM E8M (standard specimen in accordance with figure 8).

Standard specimens Charpy (V-notch) in accordance with ISO 148 -1 shall be used for determining the absorbed impact energy.

The following properties must be achieved at room temperature:

0.2 % Proof Stress (N/mm^2)	Tensile Strength (N/mm^2)	Elongation After Fracture (%)	Reduction in area %	Impact Energy (J)[1]	Hardness HBW
≥ 700	900 - 1050	≥ 11	≥ 35	≥ 20	265 - 310

[1] Average of 3 specimens and minimum value for two specimens in accordance with EN10021, where the lowest value shall be at least 14 Joule.

8.2.2 Microstructure:

Microstructure must be uniform, without porosity, excessive segregation or other inhomogeneities.

8.2.2.1 Cleanliness:

The cleanliness shall be determined as per ASTM E45 method A. Acceptance criteria:

Inclusion: Thin Series

Type A, B, C: 2 max Type D: 2.5max

Inclusions: Heavy Series

Type A, B, C, D: 1.5max

Maximum Number and dimension of globular inclusions (type D)

IR (D) = n1 + 2.5n2, IR (D) is converted to an area of 160mm^2

IR (D) ≤ 10

n = number of globular inclusions

n1 (25-50 µm); n2 (51-75 µm)

Any material discontinuities present at the inclusion must also be accounted for in determining the size of the globular inclusion.

Inclusions > 75 µm, inclusing any material discontinuities are not allowable.

8.2.2.2 Delta Ferrite content and grain size:

- **Delta ferrite content shall be < 5%.** The determination of delta ferrite content shall be performed based on analysis methods in accordance with ASTM E45 Method A, "Worst field method" with V=100:1.
- **An average grain size of 4 or finer** has to be achieved. Grain size shall be determined on the martensitic secondary grain structure in accordance with ASTM E112 or ISO643. A deviation of more than 2 grain sizes in size of individual's grains from the average grain size is not allowable.

8.3 Non-destructive Testing:

8.3.1 Test Scope:

The following Non – destructive inspections shall be performed in the as delivered condition:

- Visual inspections of all bars
- Ultrasonic examination of all bars in accordance with TWP 1204. 100% of the volume must be tested in accordance with the recording level.

8.3.2 Recording level and acceptance criteria:

- Indications of surface defects such as rolled marks shall be ground out to investigate their depth at least at both ends, in the middle of the indication and at an interval of approx. 250mm.
- Surface defects with a depth extension of ≥ 1mm are not allowable, and these areas shall be cut out of the bar.
- Ultrasonic examination of all bars in accordance with TWP 1204.
- Defects above the recording level are not acceptable.
- It shall be confirmed in writing to the BHEL that bar sections containing defects above the recording level have been cut out of the bar.
- The acceptance of material at vendor's works does not relieve the supplier of his responsibility for defects discovered at later stages.

8.3.3 Material Identity Test:

An identity test must be conducted in the as – delivered condition on all bars.

9.0 Process Qualification:

In addition to testing as per clause 8.0 of this specification, following additional testing shall be performed in process qualification (see Attachment 2). **All test results carried out during process qualification shall be submitted to BHEL for approval.**

- **Tensile tests[1]:**

The strength values (0.2% Proof Stress and Tensile Strength) in the transverse direction (specimen orientation ZQ) shall not differ by more than 10% from the corresponding longitudinal values.

- The absorbed impact energy in the transverse direction (KQ 1 -3) should not differ by more than 25% from the values in the longitudinal direction (Kl at room temperature).
- **FATT:** Determination of FATT (fracture appearance transition temperature) in accordance with ASTM A370. The FATT should be evaluated based on SEP 1670 (software). The test scope must include at least 10 specimens. FATT < 25°C is to be achieved.

In accordance with ISO 6892 -2, a tensile test (in longitudinal direction) has to be performed at 600°C. The following properties must be achieved:

0.2 % Proof Stress (N/mm^2)	Tensile Strength (N/mm^2)	Elongation After Fracture (%)	Reduction in area (%)
≥ 285	≥ 380	≥ 18	≥ 60

[1] **For case where standard specimens in transverse direction cannot be made:-**

- For tensile test specimens, a round specimen with $L_0 = 5\ d_0$ or a flat specimen with a proportionality factor of k= 5.65. Proportional specimens in accordance with Fig 8 shall be used if ASTM E8 is applied.

- An undersized specimen in accordance with ISO 148 -1 for impact test specimen. Undersize dimension to be reported.
- If dimension do not allow testing in the transverse direction, even with special specimen, testing will be carried out in the longitudinal direction only.

Intergranular Fracture:

The fraction of Intergranular fracture shall be determined over the entire brittle fracture portion of the fracture surface of the impact test specimens tested at room temperature. The fraction of Intergranular fracture shall not exceed 10%. This test is not required for materials which indicate ≥90% ductile fracture at room temperature.

Magnetic Particle Test:

Performance of MT testing by the magnetic flux leakage method, alternating current phase shifted and a field strength of 20 – 65A/cm.

Distribution, type and size of grain structure in-homogeneities (e.g. segregation or delta ferrite) shall not result in MT indications.

10.0 Identification Marking:

All bars are to be marked with following information:

- Purchase Order Number
- Size
- Material Grade
- Supplier Identification

The details are to be clearly stamped and encircled by oil paint. Each bar shall be painted with gold colour on both ends. All the bars shall be suitably packed to protect them against corrosion and damage during transportation.

Bars having maximum and minimum hardness (from which test samples are taken) shall be clearly marked by oil paint for easy identification. Their respective hardness values shall also be punched on these bars.

11.0 Documentation:

Prior to, but in no case later than the delivery of the material, an inspection certificate as per EN 10204 shall be provided to BHEL in duplicate; this certificate must contain the following data:

(a) Material code no and P.O. number
(b) Material designation
(c) Heat no., heat analysis and melting methods
(d) Complete information on all heat treatments performed
(d) Mechanical test results including hardness range and the metallurgical examination.
(e) Results of non-destructive tests, UT inspection report
(f) Confirmation of the material identity check
(g) Confirmation of the dimensions and visual inspection

12.0 Cross Referred Standard:

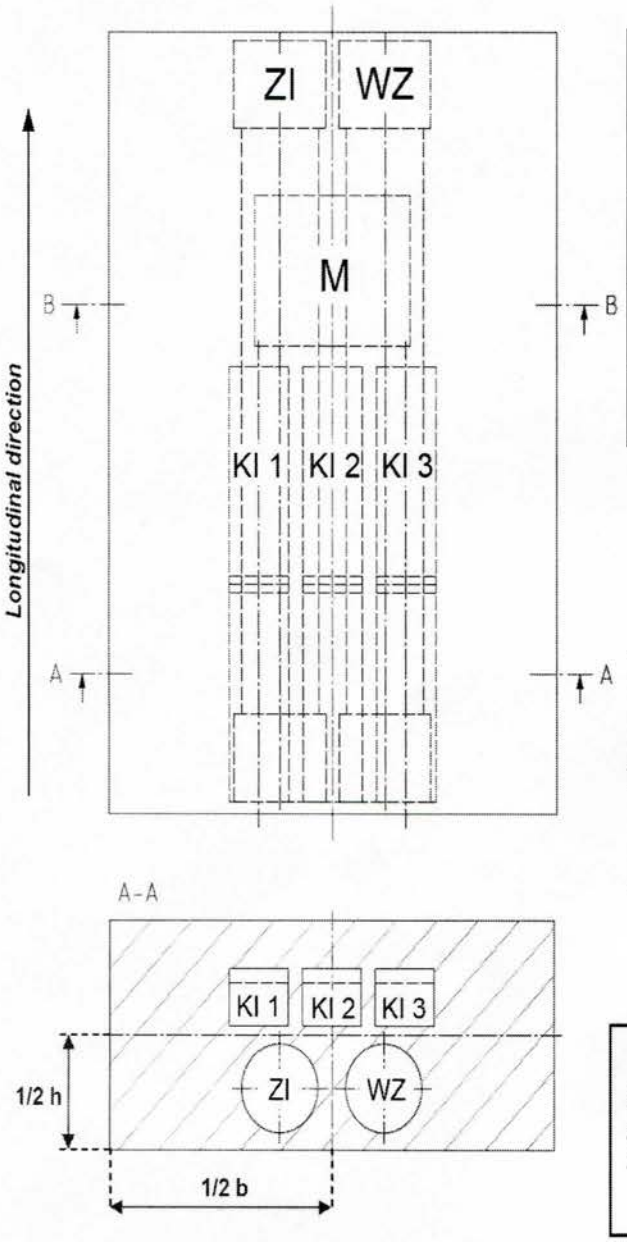
ISO 6892-1, EN10088-3, EN10021, ASTM E8M, ISO148-1, EN10021, ASTM E45, TWP1204, ASTME8, ASTM E112, ISO643, ASTM A370, EN10204

13.0 Modification with respect to last revision:

- Clause 4 modified.
- Clause 7 modified.

Attachment 1

Standard Testing



Label	Specimen
ZI	*Tensile Specimen Centre*
WZ*	*Hot Tensile Specimen*
KI 1 - KI 3	*Notched Impact Specimen Centre*
M	*Metallographic Specimen*

* *if required in material* **specification**

***Lower Surface** of the Metallographic Specimen has to be examined. Longitudinal direction must be indicated in the documentation. A ≥ 320 mm²*

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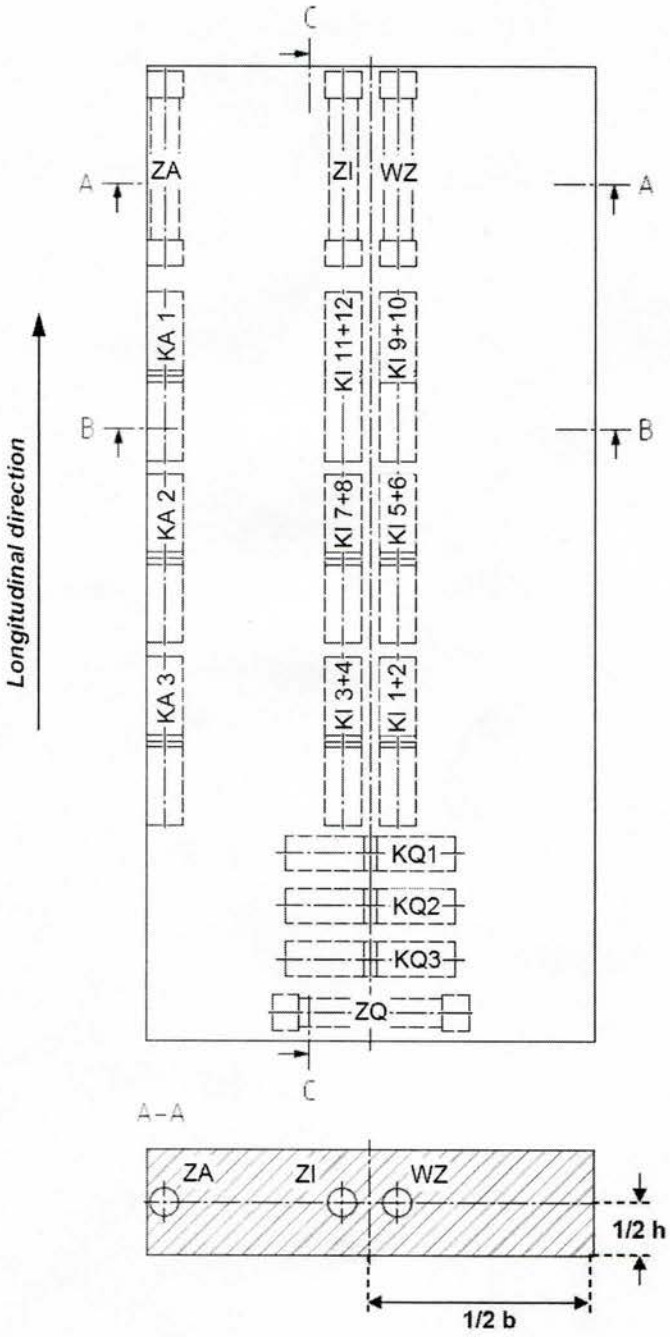
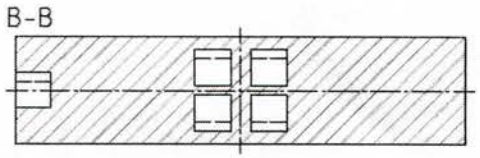
Process Qualification

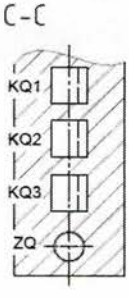


Label	Specimen
ZI	*Tensile Specimen Centre*
ZA	*Tensile Specimen Rim*
ZQ	*Tensile Specimen Transverse*
WZ*	*Hot Tensile Specimen*
KI 1 - KI 12	*Notched Impact Specimen Centre (FATT)*
KA 1 - KA 3	*Notched Impact Specimen Rim*
KQ 1 - KQ 3	*Notched Impact Specimen Transverse*

* *if required in material* **specification**

Note the notch positions of the notch impact specimens (see B - B and C - C).





REV 06

निर्माणकर्ता WORKED BY	Ashish Ranjan		26.10.15
जांचकर्ता CHECKED BY	Gopal Krishnan		26.10.15

स्वीकृत सूची संख्या को प्रतिस्थापित करता है SUPERSEDES INVENTORY NO

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A-2008

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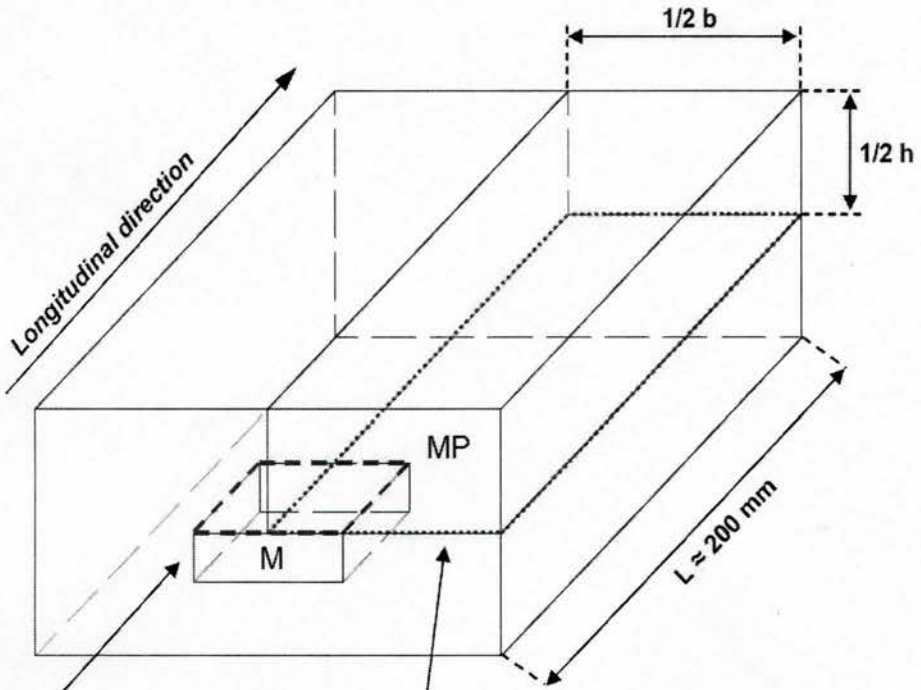
Process Qualification

Label	Specimen
M	*Metallographic Specimen*
MP	*Specimen for Magnetic Particle Test*



***Upper Surface** of the Metallographic Specimen has to be examined. Longitudinal direction must be indicated in the documentation. A ≥ 320 mm²*

***Lower Surface** of the specimen has to be examined in Magnetic Particle Test .*